ORIGINAL RESEARCH ARTICLE

Study of Effects of Cooking Fuels Biomass and LPG on Pulmonary Function Tests in Rural Women of Punjab.

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Abstract: -

Introduction: The deleterious effects of indoor air pollution by using different cooking fuels is of great concern for respiratory health. Present study was conducted to study and compare the effects of two major fuels habitually used in developing countries like India. The chief among many are biomass fuel and Liquefied Petroleum Gas (LPG). Their effect on different respiratory functions in rural women of Amritsar, India was studied and compared by using computerized spirometer. Material & Methods: Study was conducted on 800 rural women out of which 400 using Biomass as cooking fuel and rest 400 using LPG. Subjects of chronic and recent respiratory illness even if treated were excluded. Ventilatory functions of lungs were done on computerized spirometer, MED-SPIROR. Results: There was statistically significant decline in FEV_1 in women using biomass fuel (0.70±0.15) when compared with women using LPG (1.86±0.37). Other parameters FEV3, PEFR, FEF 25-75%, FEF2-12, FEF 25%, FEF 50% FEF 75% and MVV showed similar significant decline in women using Biomass as fuel. Conclusion: There is significant decline in ventilatory function of lungs in women using Biomass as cooking fuel. This being still used in developing country like India so reduced values indicate small airway obstruction need continuous review by policy makers as well as for educating the folks.

Key words: Cooking fuel, pollution, COPD, FEV_1, biomass fuel, LPG

Abbreviations: LPG: Liquefied petroleum gas; FVC: Forced vital capacity; FEF: Forced Expiratory Flow; MVV: Maximum Voluntary Ventilation.

Introduction:

Of late the unhealthy effects of air pollution, in both industrial workers as well as rural folks have been of great concern for mankind since several decades. The outdoor pollution is most serious concern by industrial pollutants both in industrial workers1 as well as in closely residing population. The most common cause of indoor air pollution in rural areas is the smoke emission by combustion of very common domestic cooking fuels especially biomass, kerosene & coal.

Not only the type of cooking fuel but the location of the kitchen, the type of ventilation and the type of cooking device used are the major determinants of the level of pollution and their effects [3] on respiratory tract. Commonly four types of fuels and their specific fireplace devices are used in India.

These include: (i) Biomass fuel consisting of cow dung, wood and agricultural wastes in common household fireplace termed *chullah.* (ii) Kerosene oil used in Kerosene stove (iii) Liquid petroleum Gas used in gas stove (iv) Wooden and industrial coal used in specific fireplace called *Angithi*. Combustion of these fuels produces several important pollutants such as carbon-monoxide, oxides of nitrogen and sulphur, suspended

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particulate matter and many organic compounds [4]. Incomplete combustion is more hazardous [5]. Various researchers have reported an association of increased incidence of chronic obstructive pulmonary disease with combustion of these fuels. The deleterious effects are more with biomass fuel [6].

Thus the screening of pulmonary functions of rural women has become essential for early recognition of the damage caused to the pulmonary tissue due to exposure to high levels of smoke and noxious fumes liberated from the combustion of cooking fuels. Biomass, coal and kerosene [7] are chief pollutants. The early diagnosis of lung function impairment can provide an important clue to prevent permanent respiratory disability and ensure good health & safety of women using cooking fuels [8]. The diagnosis and treatment of some of chief respiratory disorders depends heavily on understanding basic physiology of pulmonary function tests [9].

Spirometry is a simple, non-invasive method of assessing lung function tests [10]. Various types of spirometers are being used till date but the availability of sophisticated and computerized Spirometer 'Med-Spiror,' is a revolutionary measure for assessment of respiratory system in terms of volumes in slow or forced expiration [11]. It is good screening test to identify airflow obstruction and in rating disability to combustion of cooking fuels [12].

It is estimated that globally 2.5 to 3 billion people rely on these fuels for everyday household energy needs. The majority of those exposed are women, infants/young children. Women are normally performing duty of cooking, and young children usually stay with their mothers near the cooking area. Although the fraction of global energy from bio-fuel has fallen from 50 percent in 1900 to around 13 percent currently, this trend has leveled off and there is evidence that biomass fuel use is increasing among the poor in some parts of the world.

There is consistent evidence that exposure to biomass smoke increases the risk of a range of common and serious diseases of both children and adults. Reduction in ventilator functions is reported with use of biomass fuel [13]. Acute and chronic respiratory effects of domestic fuel combustion include chronic obstructive pulmonary disease [14], Asthma [15], Cor-pulmonale, bronchiectasis [16], nasopharyngeal cancer [17], acute lower respiratory illness (ALRI) in children [18] and exacerbations of asthma [19]. There are increased levels of carbon monoxide in nonsmoking women using different cooking fuels [20]. Nitrogen dioxide damages lung directly through its oxidant properties or indirectly by increasing its susceptibility to infections.

Materials and Methods:

Present study was conducted in the villages adjoining Amritsar (India) city. 800 nonsmoker rural female subjects in the age group of 18-45 years were selected for study. Out of them 400 women were using LPG and 400 women using Biomass fuel. Subjects having existing respiratory diseases like asthma, persistent cough, Tb, COPD and also those treated recently for any respiratory illness were excluded.

Parameters: The following parameters were studied Body surface area (B.S.A.). Forced vital capacity (F.V.C.). Forced expiratory volumes (FEV_1, FEV_2, FEV_3 over fixed time intervals (T=0.5, 1 & 3 seconds).

Maximum mid expiratory flow rate FEF (25-75%)

Peak expiratory flow rate (PEFR). Maximum voluntary ventilation (MVV).

Forced expiratory flow after 25% FVC has been expired (FEF 25%).

Forced expiratory flow after 50% FVC has been expired (FEF 50%).

Forced expiratory flow after 75% FVC has been expired (FEF 75%).

Observations & Results:

Table 1: Comparison of Mean expiratory parameters in rural women using LPG & biomass fuel

Parameters	LPG-Users	Biomass –Users	P-Value	Significance
FVC	1.91±0.37	0.73±0.15	<0.001	HS
FEV0.5(L)	1.72±0.40	0.64±0.14	<0.001	HS
FEV1(L)	1.86±0.37	0.70±0.15	<0.001	HS
FEV3(L)	1.90±0.37	0.71±0.15	<0.001	HS
PEFR(L/sec)	4.42±0.94	1.76±0.41	<0.001	HS
FEF25-75(L/sec)	3.24±0.76	1.47±0.36	<0.001	HS
FEF2-12(L/sec)	3.48±0.89	1.45±0.33	<0.001	HS
FEF25%(L/sec)	3.69±0.94	1.56±0.38	<0.001	HS
FEF50%(L/sec)	3.32±0.77	1.57±0.39	<0.001	HS
FEF75%(L/sec)	2.87±0.72	1.42±0.36	<0.001	HS
FEV0.5/FVC%	90.45±15.47	87.78±10.77	<0.001	HS
FEV1/FVC%	97.54±8.15	95.98±2.37	<0.001	HS
FEV3/FVC%	99.68±0.32	97.48±0.30	<0.001	HS
MVV(L/min)	77.21±7.60	25.99±5.13	<0.001	HS

FVC (Forced vital capacity in litres): (Table 1.) In the present study mean FVC was 1.91 in LPG fuel users and 0.73 in biomass fuel users. This showed that difference in FVC between two groups was highly significant. FVC declined by 61.8% in biomass fuel users when compared with LPG fuel users.

FEV0.5 (Forced expiratory volume in 0.5 second in litres): In present study FEV0.5 in LPG fuel users was 1.72 & in biomass fuel users was 0.64. It was decreased by 63% in biomass fuel users when compared with LPG fuel users.

FEV1 (Forced expiratory volume in one second in litres): In the present study FEV1 was 1.86±0.37 in LPG fuel users and 0.70±0.15 in biomass fuel users. Thus FEV1 was decreased by 62% in biomass fuel users when compared with LPG fuel users. Decrease in FEV1 reflects obstructive pattern of impairment as a result of mucosal edema and superimposed infection, broncho constriction substances.

FEV3 (Forced expiratory volume in 3 seconds in litres): In the present study there was highly significant decrease in FEV3 in biomass fuel users (0.71±0.15) when compared with LPG users (1.90±0.37).

PEFR (Peak expiratory flow rate in litres/sec):
In the present study PEFR decreased from 4.42±0.94 in LPG fuel users to 1.76±0.41 in biomass fuel users. So PEFR decreased by 60% in case of biomass fuel users when compared with that of LPG fuel users.

PEFR is the better measure for large airways obstruction. Decrease in PEFR caused by irritant gases and particulate matter is due to hypertrophy of mucosal cells and superimposed infection due to ciliastasis.

FEF25-75% (Mean forced expiratory flow during middle half of FVC IN L/sec): In the present study FEF25-75% showed decline in biomass fuel users(1.47±0.36) when decline was highly significant. FEF25-75% is a good index of early obstruction in small airways.

FEF2-12 (Mean forced expiratory flow rate between 0.2-1.2 litres of volume change in litres/sec): In the present study FEF2-12 showed highly significant decrease in biomass fuel users(1.45±0.33) when compared to LPG fuel users.

FEF25% (Forced expiratory flow rate after 25% of FVC has been expired in litres/second):
In the present study FEF25% decreased from 3.64±0.94 (in case of LPG fuel users) to 1.56±0.38 (in case of biomass fuel users).

FEF50% (Forced expiratory flow after 50% of FVC has been expired in litres/second): In the present study FEF50% decreased from 3.32±0.77 (in LPG fuel users) to 1.57±0.39 (in biomass fuel users.

FEF75% (Forced expiratory flow after 75% of FVC has been expired in litres/second):
In the present study FEF75% showed highly significant decline in biomass fuel users (1.42±0.36) as compared to LPG fuel users (2.87±0.72). It is also important indicator of small airway obstruction.

FEV0.5/ FVC% Percentage ratio of forced expiratory volume in 0.5 second to forced vital capacity: In the present study showed that FEV0.5 /FVC% decreased from 90.45±15.47 (in case of LPG fuel users) to 87.78±10.77.

FEV1/ FVC% (Percentage ratio of forced expiratory volume in 1 second to forced vital capacity: In the present study FEV1/FVC% decreased from 97.54±8.15 (in LPG fuel users) to 95.98±2.37(in case of biomass fuel users).It was significant decline($p>0.05$). It is better indicator of obstructive type of lung disease.

FEV3/FVC% (Percentage ratio of forced expiratory volume in 3 seconds to forced vital capacity: In the present study FEV3/FVC% ratio declined from 99.68±0.32 in LPG fuel users to 97.48±0.30 in biomass fuel users. Decline was significant ($p<0.05$).

MVV (Maximum voluntary ventilation in litres/minute): In the present study MVV decreased by 66% in biomass fuel users (27.14±6.24) as compared to LPG fuel users (77.21±7.60). It was highly significant decline ($p<0.001$). MVV is good guideline of mechanical efficiency of lungs. Reduced MVV is indicator of obstructive insufficiency. Thus smoke emitted from kerosene decreased mechanical efficiency of lungs and obstructive impairment.

Discussion:

The present study was done to collect more information about lung functions in rural women of Punjab using LPG & Biomass fuel. The sample of 800 women in the study is presumed to represent a cross section of rural women of Punjab vis-a-vis rest of India and developing world. The respiratory health is adversely affected with indoor and outdoor pollution. Each parameter has been dealt with separately explaining the changes in these two types of fuel users. It also showed changes in these parameters with number of years of exposure.

In the present study mean FVC was 1.91 in LPG fuel users and 0.73 in biomass fuel users. This showed that difference in FVC between two groups was highly significant.FVC declined by 61.8% in biomass fuel users when compared with LPG fuel users. Similar changes in FVC due to smoke have been reported in earlier studies [21].

FEV1(Forced expiratory volume in one second in litres): In the present study FEV1 was 1.86±0.37 in LPG fuel users and 0.70±0.15 in biomass fuel users. Thus FEV1 was decreased by 62% in biomass fuel users when compared with LPG fuel users. Findings in our study are concurrent with earlier studies, [22]. Decrease in FEV1 reflects obstructive pattern of impairment as a result of mucosal edema and superimposed infection, broncho constriction substances.

FEV3 (Forced expiratory volume in 3 seconds in litres): In the present study there was highly significant decrease in FEV3 in biomass fuel users

(0.71±0.15) when compared with LPG users (1.90±0.37).

PEFR (Peak expiratory flow rate in litres/sec):

In the present study PEFR decreased from 4.42±0.94 in LPG fuel users to 1.76±0.41 in biomass fuel users. So PEFR decreased by 60% in case of biomass fuel users when compared with that of LPG fuel users. Similar decrease in PEFR due to smoke and dust has been reported in previous studies [23,24].

PEFR is the better measure for large airways obstruction. Decrease in PEFR caused by irritant gases and particulate matter is due to hypertrophy of mucosal cells and superimposed infection due to ciliastasis.

FEF 25-75% (Mean forced expiratory flow during middle half of FVC IN L/sec): In the present study FEF 25-75% showed decline in biomass fuel users (1.47±0.36) when decline was highly significant. FEF25-75% is a good index of early obstruction in small airways.

FEF2-12 (Mean forced expiratory flow rate between 0.2-1.2 litres of volume change in litres/sec): In the present study FEF2-12 showed highly significant decrease in biomass fuel users(1.45±0.33) when compared to LPG fuel users.

FEF25% (Forced expiratory flow rate after 25% of FVC has been expired in litres/second):

In the present study FEF25% decreased from 3.64±0.94 (in case of LPG fuel users) to 1.56±0.38 (in case of biomass fuel users).

FEF50% (Forced expiratory flow after 50% of FVC has been expired in litres/second): In the present study FEF50% decreased from 3.32±0.77 (in LPG fuel users) to 1.57±0.39 (in biomass fuel users.

FEF75% (Forced expiratory flow after 75% of FVC has been expired in litres/second):

MVV (Maximum voluntary ventilation in litres/minute): In the present study MVV decreased by 66% in biomass fuel users (27.14±6.24) as compared to LPG fuel users (77.21±7.60). It was highly significant decline ($p<0.001$) Decrease in MVV is in accordance to earlier study [25].

The World Health Organization (WHO) revealed indoor air pollution as the eighth most important risk factor responsible for 2.7% of the global burden of disease. Around 3 billion people use solid fuels (biomass and coal) for cooking and heating, and this number is expected to grow until 2030. In countries like India, Nepal, Pakistan, and Sri Lanka usage of biomass fuel is 72%, 88%, and 67%, respectively for daily household cooking. According to the National Family Health Survey-3, about 33.9% of rural households in India do not have separate room for cooking. Symptoms such as eye irritation, shortness of breath, cough, and dizziness are highly prevalent among biomass fuel users. Both systolic and diastolic blood pressure showed a strong relationship with the number of years of exposure with biomass. The conclusion reached at by present study has been compared with those derived from other studies in the past. As shown in Table 1 in the study of mean FVC (1.91 vs 0.73) showed that difference between two groups was highly significant showing decline by 61.8% in biomass fuel users when compared with LPG fuel users. Similar changes in FVC due to smoke have been reported in earlier studies [21]. Similarly in our study MVV decreased by 66% in biomass fuel users (27.14±6.24) as compared to LPG fuel users (77.21±7.60). It was highly significant decline ($p<0.001$) Decrease in MVV is in accordance to earlier study [25]. MVV is good guideline of mechanical efficiency of lungs. Reduced MVV is indicator of obstructive insufficiency. Thus smoke emitted from kerosene decreased mechanical efficiency of lungs and obstructive impairment.

Conclusion:

In present study there was decline in FVC in biomass fuel users which indicate restrictive insufficiency. There was also decline in FEV1, FEV1/FVC%, MVV which indicated obstructive impairment. There was also decrease in PEFR which indicates large airway obstruction. Reduced values were also seen for FEF 25-50% and FEF 75% which indicates small airway obstruction. Thus in present study there is decline in all these parameters which indicates biomass fuel combustion causes both restrictive and obstructive impairment of the lungs. Obstruction was seen in both large and small airways. This is mainly due to carbon-monoxide, sulfur dioxide and nitrogen-dioxide due to biomass combustion.

Measures that needs to be taken to minimize indoor air pollution, Proper ventilation, Source substitution, Source modification, Air cleaning- gas absorbers, air filters, Behavioral adjustment.

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